Marine Fouling Studies off Oahu, Hawaii

BY

EDWARD R. LONG

Ocean Analysis Division, United States Naval Oceanographic Office, Washington, D. C. 20373 [1]

(1 Plate; 4 Text figures)

INTRODUCTION

Fouling, which results from the attachment and growth of plants and animals on submerged man-made objects, often has harmful effects upon these objects. Fouling organisms increase the frictional resistance of ship's hull to movement through water, decreasing speed and efficiency while increasing operating costs. Organisms which attach inside pipes and conduits decrease or prevent water flow through the pipes. The accuracy and usefulness of sonar and other submerged sound producing and detecting equipment are decreased by the reflection, scattering, and adsorption of sound waves by fouling. Some calcareous, cementing organisms, especially barnacles, cause or accelerate mechanical or chemical destruction, or both, of metallic surfaces and the paints used to coat these surfaces.

In contrast to these harmful effects, fouling occasionally is beneficial to marine scientists and engineers. Dense fouling accumulations can effectively camouflage submerged ordnance and other equipment. By closely examining the kinds and amounts of organisms attached to derelict objects, marine biologists can determine the origin and time-in-water of these objects. Fouling organisms can be used as indicators of changing environmental quality in coastal and harbor waters. Patterns in the colonization of unpopulated substrates by sessile benthic communities and the successional processes of these communities can be documented, using fouling study techniques.

The U. S. Naval Oceanographic Office (NAVOCEANO) has been studying marine fouling at numerous sites world-wide since 1955. These studies have been directed at gathering data on the abundance, community composition, depth distribution, and seasonality of attachment of fouling organisms. From February 1968 to May 1972 test panels were exposed to obtain the above information on fouling in Pearl Harbor and the coastal waters of the island of Oahu. Tests were also conducted to determine preferences of fouling organisms for various materials and for various sizes of test panels.

Several reports have been written on past fouling research in the waters of Oahu. Hutchins (1949) reviewed and summarized much of the work J. P. Visscher conducted from 1935 to 1937 on the fouling of ships' hulls and wood test blocks, mainly in Pearl Harbor. Later, from 1939 to 1944, Edmondson and Ingram duplicated some of Visscher's Pearl Harbor work and initiated new studies in Kaneohe Bay, in the entrance to Pearl Harbor and offshore near Barber's Point (Edmondson, 1942, 1944; Edmondson & Ingram, 1939). Edmondson (1946) included fouling data in compiling information on the nearshore fauna of the Hawaiian Islands. Wood test panels were exposed pierside in Pearl Harbor from 1948 to 1962 by the William F. Clapp Laboratories. The borer and fouling data obtained were presented in progress reports to the U. S. Bureau of Yards and Docks (*e.g.*, Wallour, 1959; U. S. Bureau of Yards and Docks, 1951).

The occurrence of fouling bryozoans observed at numerous Oahu locations was documented by Soule & Soule (1967, 1968, 1970). Initial NAVOCEANO fouling studies were conducted off Ewa Beach and Barber's Point (Long, 1969, 1970). McVey (1971) described the fishes and sessile organisms to a concrete pipe artificial reef in Pokai Bay off the leeward shore of Oahu. The accumulation of microbial fouling organisms on opaque surfaces was studied in Kaneohe Bay (Sechler & Gundersen, 1971; Sechler, in press). The benthic communities attached to pilings throughout upper Pearl Harbor were described and compared by Evans, *et al.* (1972).

The relative amounts and kinds of fouling organisms accumulated by various materials and surface textures have been determined by various authors, including Edmondson & Ingram (1939) in Hawaii, Pomerat & Weiss

[1] Present address: WAPORA Inc., 6900 Wisconsin Avenue, N. W. Washington, D. C. 20015

(1946) in Florida, and Crisp & Ryland (1960) in North Wales. None of these authors analyzed the assemblages collected on the various materials by using a faunal similarity coefficient. No data have appeared in the literature on the relative numbers of species and the biomass per unit area collected by test panels of varying surface areas.

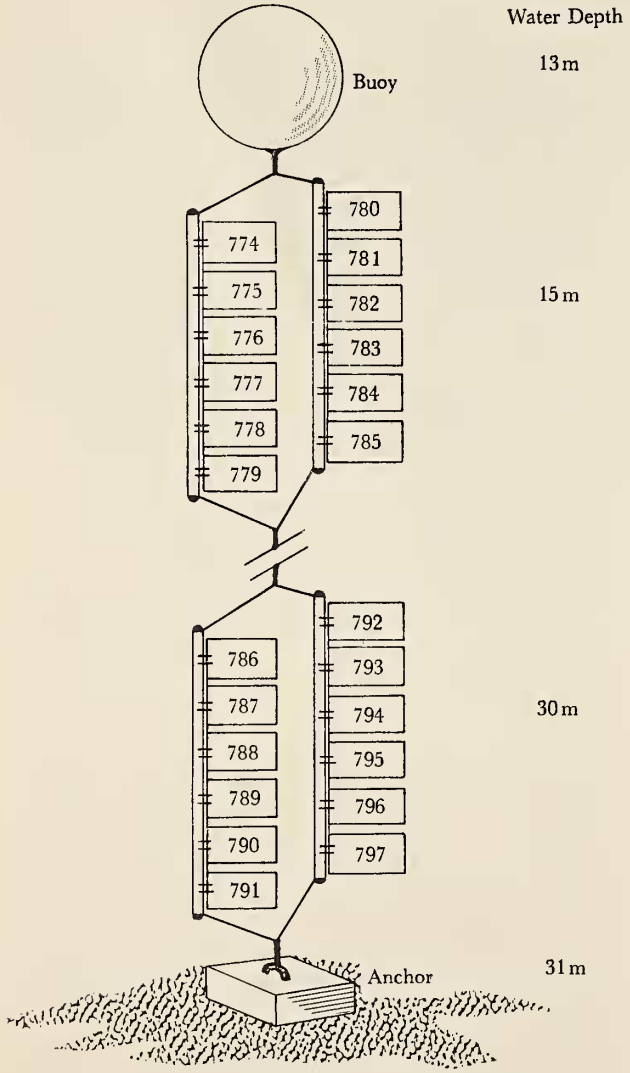


Figure 1
Configuration of Offshore Test Array and Location of Test Panels

MATERIALS AND METHODS

Standard NAVOCEANO test panels composed of 15 × 30 × 0.5 cm black, Johns-Manville, Colorlith (asbestos) plates attached to 15 × 30 × 2 cm pinewood blocks were used in this study. Offshore the test panels were secured to 1.5 m high racks on vertical arrays at depths of 15 m and 30 m as shown in Figure 1. In Pearl Harbor a small buoyed rack holding six test panels was placed near the bottom, 9 m deep.

Test panels were exposed at three sites (Figure 2). Site 1 was located in approximately 31 m of water 2.1 km off Ewa Beach at 21°17′19″N, 158°02′02″W. Site 2, in approximately 33 m of water at 21°19′02″N, 158°08′01″W, was 1.3 km offshore. Site 2 was probably within 4 km of the position where Edmondson's 1944 Barber's Point buoy array was exposed. Site 3 was located 1.85 km inside the entrance to Pearl Harbor in 9 m of water at 21°20′13″N, 157°58′32″W. Data were collected from February 1968 to December 1969 at site 1, from March 1969 to May 1972 at site 2, and from April 1970 to May 1972 at site 3.

U. S. Navy SCUBA divers attached and removed test panels from the racks according to a predetermined schedule as weather and priority operations allowed. After one month's initial exposure, one test panel was removed from each rack and replaced by a new one. Thereafter, two test panels, one having been exposed for a month and the other since the beginning of the study, were removed monthly and a new panel attached for a month-long exposure. Thus, data were collected on settlement and community development for monthly and longer periods up to 12 months. Additionally, two test panels were left on their racks at site 2 for 25 months. Retrieved panels were soaked in ethyl alcohol, wrapped in zippered plastic bags, packaged, and shipped to NAVOCEANO for analysis. The divers collected water samples for salinity determinations and measured water temperatures at test panel depths during most dives.

During the 1971–1972 study year only, pyramidal bottom racks were implanted 36 m deep at site 2 and 9 m deep at site 3. Clear plexiglass, grey PVC (poly vinyl chloride), black plastic, black unpainted steel, and painted (green non- antifouling paint) steel test panels measuring 15 × 30 × 0.5 cm were exposed for three 3-months and one 4-months period (15 April to 15 July, 15 July to 15 October, 15 October to 15 January, 15 January to 15 May) to determine relative abundance and community composition of the fouling attached to the materials. Simultaneously, 15 cm wide × 0.5 cm thick asbestos test panels measuring 15 cm, 30 cm, 61 cm, 91 cm, and 122 cm in length were exposed on the vertical arrays for 3, 4, and 13-months periods. These test panels were used to determine the optimum

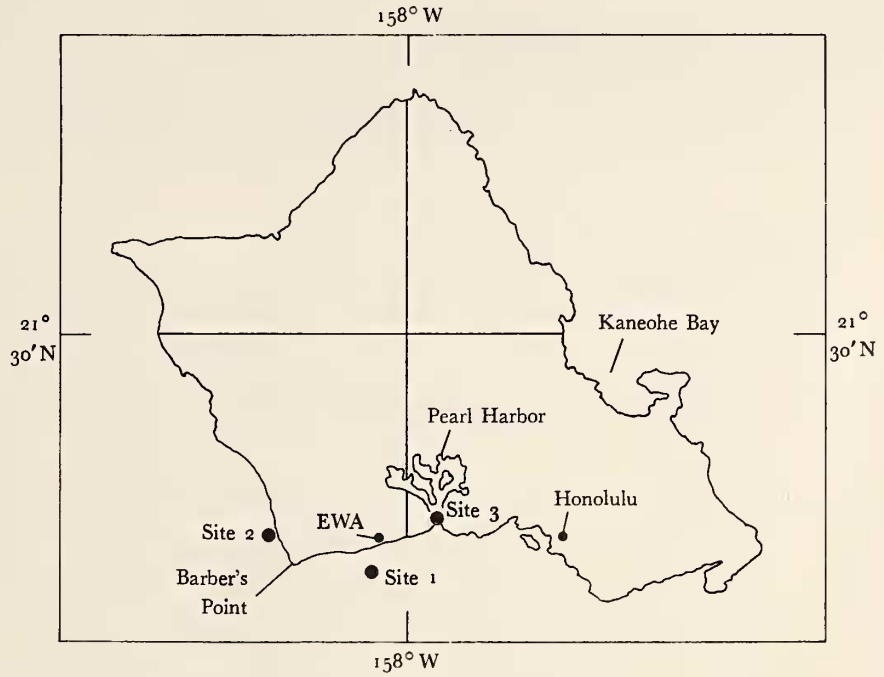


Figure 2
Test Site Locations, Oahu

size for collecting representative numbers and species of attached fouling and to determine whether or not significantly more species and organisms would attach to test panels larger than the standard NAVOCEANO 15 × 30 cm surfaces.

Analyses of all test panels included identification of the organisms, determination of the maximum size of each species present, estimation of the percent of the surface area covered by each species, and measurement of the maximum thickness of the fouling. After the above analyses, all fouling organisms were scraped from the test panels and oven-dried to determine dry weight biomass.

Many specific identifications of fouling organisms were made by various specialists credited in Acknowledgments. Tentative identifications of other species were made by the author using the following publications: algae (Neal, 1930); sponges (DeLaubenfels, 1957, and Bergquist, 1967); corals and hydroids (Edmondson, 1946, and Vaughan, 1907); bryozoans (Soule & Soule, 1967, 1968, 1970; and Osburn, 1950, 1952, 1953); Mollusks (Dall, Bartsch, & Rehder, 1938); barnacles (Edmondson, 1946, and Southward & Crisp, 1963); and ascidians (Eldridge, 1966).

The relative similarity between assemblages of fouling collected on the six materials was determined by means of a coefficient of faunal similarity (Simpson, 1960), $J = \frac{2C}{N_1 + N_2}$, called the Dice Coefficient by Sokal & Sneath (1963) and Cheetham & Hazel (1969). This coefficient, which is usually used to compare quantitative binary (presence-absence) data, was modified to incorporate the relative abundance or importance of each species as well as their presence or absence. This was done by, first, adding the total percentage of each of two test panel surfaces covered by all species, N_1 and N_2, respectively. Then, the percentages of coverage of each species on two test panels were compared and the smaller of the two was taken as the "common abundance value," C. These C values were summed for each pair of test panels compared and the Dice Coefficients were calculated. This method of using relative abundance, or rank correlations, has been employed by Sanders (1960), Wieser (1960), and Bray & Curtis (1957) to measure marine soft bottom, marine meiofauna, and terrestrial forest communities, respectively. Whitaker & Fairbanks (1958) used a similar technique, called the "percentage similarity" of community

samples, to measure planktonic copepod communities by numbers of individuals of species. Fager (1957, 1963) discussed the advantages and disadvantages of binary coefficients and "rank correlation" coefficients.

RESULTS and DISCUSSION

A total of 342 test panels exposed for varying lengths of time at the three sites was examined. Fouling was moder-

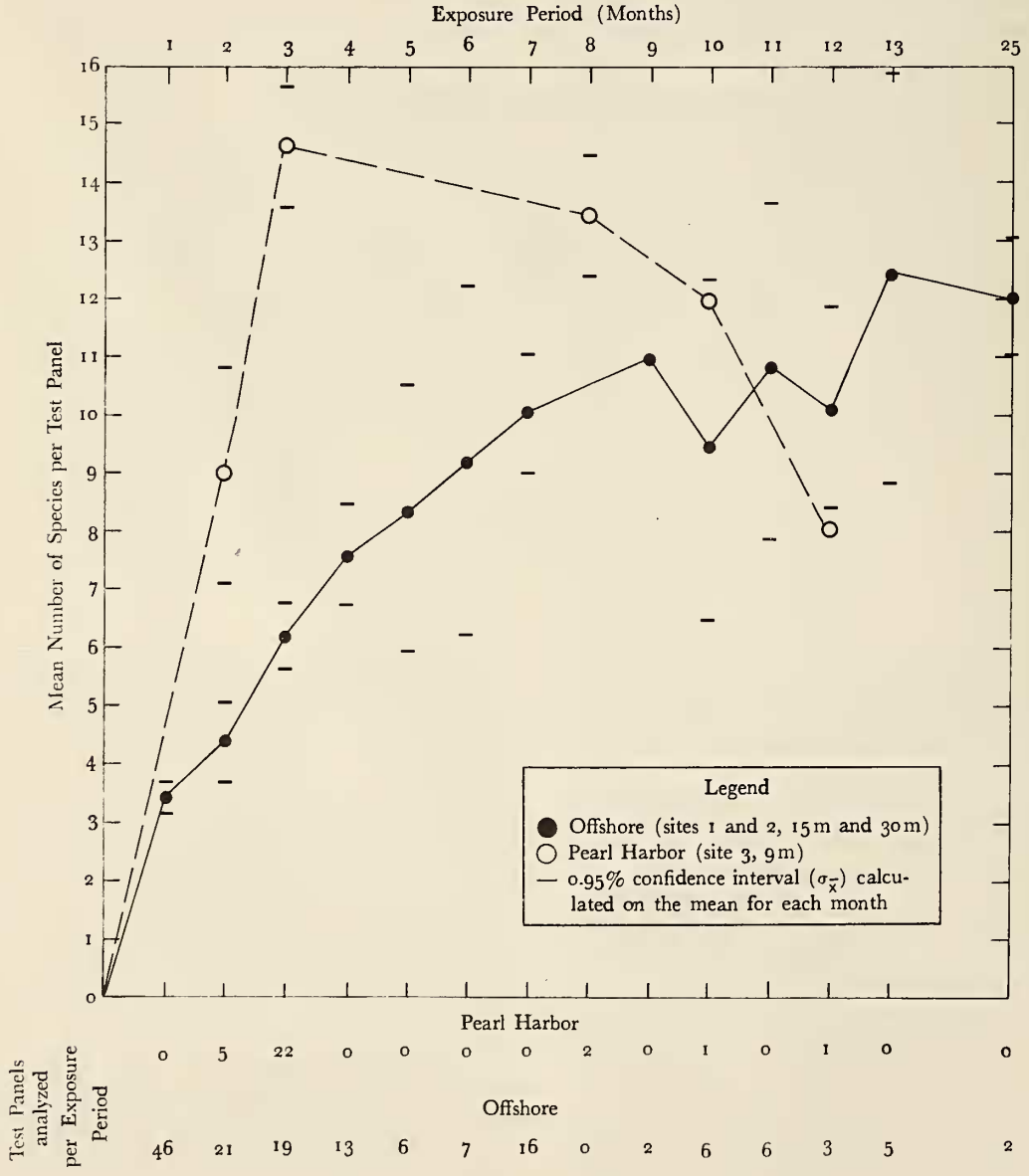


Figure 3

Mean Rates of Colonization of Offshore and Pearl Harbor Asbestos Test Panels and the Numbers of Test Panels Analyzed per Exposure Period During 1968, 1969, 1970, and 1971

Table 1

Comparative Abundance of Fouling Organisms Offshore (15 and 30/36 m) and in Pearl Harbor (9 m). Comparative abundance values were determined by tabulating for each species the average percent coverage on all test panels: Dominant species (XXX) continually occupy 41 to 100% of the area of test panels; Influents (XX), 6 to 40%; and Trace (X), 5% or less.

Species	Depth		
	Offshore		Pearl Harbor
	15 m	30/36 m[1]	9 m
Algae:			
Chrysonephos lewisii (Taylor, 1951)	X	X	X
Unidentified colonial diatoms	XXX	XXX	X
Enteromorpha intestinalis (Linnaeus, 1755)	X	X	
Codium dichotomum (Hudson, 1762) Setchell, 1931	X		
Dictyota divaricata Lamouroux, 1809	XX	XX	
Padina pavonica (Linnaeus, 1753) Thivy, 1960	XX	XX	
Unidentified calcareous alga		X	X
Miscellaneous red and green algae	X	X	
Sponges:			
Unidentified demospongiae			X
Sycon sp.	X	X	
Coelenterates:			
Pennaria tiarella McCrady, 1857	XXX	XX	X
Obelia sp.	X	X	
Plumaria cf. *goodei* Nutting, 1900	X		
Pocillopora cespitosa laysanensis Vaughan, 1907	X	X	
Pocillopora meandrina Dana, 1846	X		
Unidentified rose coral		X	
Unidentified purple alcyonarian			X
Unidentified pink gorgonian	X		
Bryozoans:			
Aetea truncata (Landsborough, 1852)	XXX	XXX	
Steganoporella sp.		X	
Bugula neritina (Linnaeus, 1758)	X		XX
Bugula californica Robertson, 1905	X		
Beania discodermiae (Ortmann, 1890)		X	
Scrupocellaria sinuosa Canu & Bassler, 1927	X	X	
Mastigophora sp.		X	
Thalamoporella hawaiiana Soule & Soule, 1970	XX	XX	
Cribrilaria radiata (Moll, 1803)		X	
Savigniella lafontii (Audouin, 1826)			X
Vittaticella elegans (Busk, 1852)	X		
Watersipora edmondsoni Soule & Soule, 1968	X		X
Schizoporella unicornis (Johnston, 1847)	X		X
Reteporellina denticulata (Busk, 1884)	X	X	
Rhynchozoon sp.		X	
Microporella ciliata (Pallas, 1766)		X	X
Parasmittina spathulata (Smitt, 1873)	X	X	
Parasmittina sp.			X

[1] Species found on vertical arrays 30 meters deep and on bottom rack 36 meters deep are combined under OFFSHORE—30/36 METERS designation.

Table 1 [continued]

Species	Depth: Offshore 15 m	Depth: Offshore 30/36m[1]	Depth: Pearl Harbor 9 m
Celleporaria vagans (Busk, 1855)	X	X	X
Celleporina costazii (Audouin, 1826)		X	
Amathia sp.	X		
Bowerbankia sp.	X		
Tubulipora sp.	X	X	
Lichenopora sp.	X	X	X
Mollusks:			
Crepidula aculeata Gmelin, 1791	X		XXX
Crucibulum spinosum (Sowerby, 1824)			X
Dendropoma sp.	X		X
Unidentified vermetid	X	X	X
Septifer bryanae Pilsbry, 1921	X	X	
Pteria loveni (Dunker, 1872)	X	X	
Pinctada margaritifera (Linnaeus, 1758) see Ranson, 1961, pg. 52–77, plates XXIX–XXXVII	X	X	
Pinna muricata Linnaeus, 1758; see Rosewater, 1961, pg. 188–193, plate 141	XX	X	
Spondylus gloriosus Dall, Bartsch & Rehder, 1938	X	X	
Anomia nobilis Reeve, 1859	X		X
Ostrea kavaia Dall, Bartsch & Rehder, 1938	XXX	XXX	X
Ostrea sandvichensis var. *thaanumi* Dall, Bartsch & Rehder, 1938	XX	XX	X
Ostrea frons Linnaeus, 1758		X	X
Sphenia cf. *fragilis* (H. & A. Adams, 1854)			X
Tubeworms:			
Hydroides norvegica Gunnerus, 1768	XX	XX	X
Hydroides crucigera Morch, 1863	X	X	X
Hydroides dirampha Claparede, 1868	XX	X	X
Hydroides sanctaecrucis Morch, 1863	X		
Hydroides uncinata Phillipe, 1844	X		
Hydroides elegans Haswell, 1883			X
Spirobranchus tricornis Morch, 1863	X		
Salmacina dysteri Huxley, 1855	XX	X	X
Unidentified sabellid	X		X
Barnacles:			
Balanus amphitrite, Darwin, 1854	XX	XX	XX
Balanus eburneus Gould, 1841	X		XXX
Balanus trigonus Darwin, 1854	X	X	X
Balanus tintinnabulum (Linnaeus, 1758)	X		
Balanus crenatus Bruguiere, 1789		X	
Tunicates:			
Herdmania momus (Savigny, 1816)	X	X	X
Ascidia melanostoma (Sluiter, 1885)	X		X
Didemnum sp.			XXX
Polyclinum vasculosum Pizon, 1908	X		XX
Unidentified small white simple	X	X	
Unidentified red/purple compound		X	
Total Species:	56	45	36

[1] Species found on vertical arrays 30 meters deep and on bottom rack 36 meters deep are combined under OFFSHORE—30/36 METERS designation.

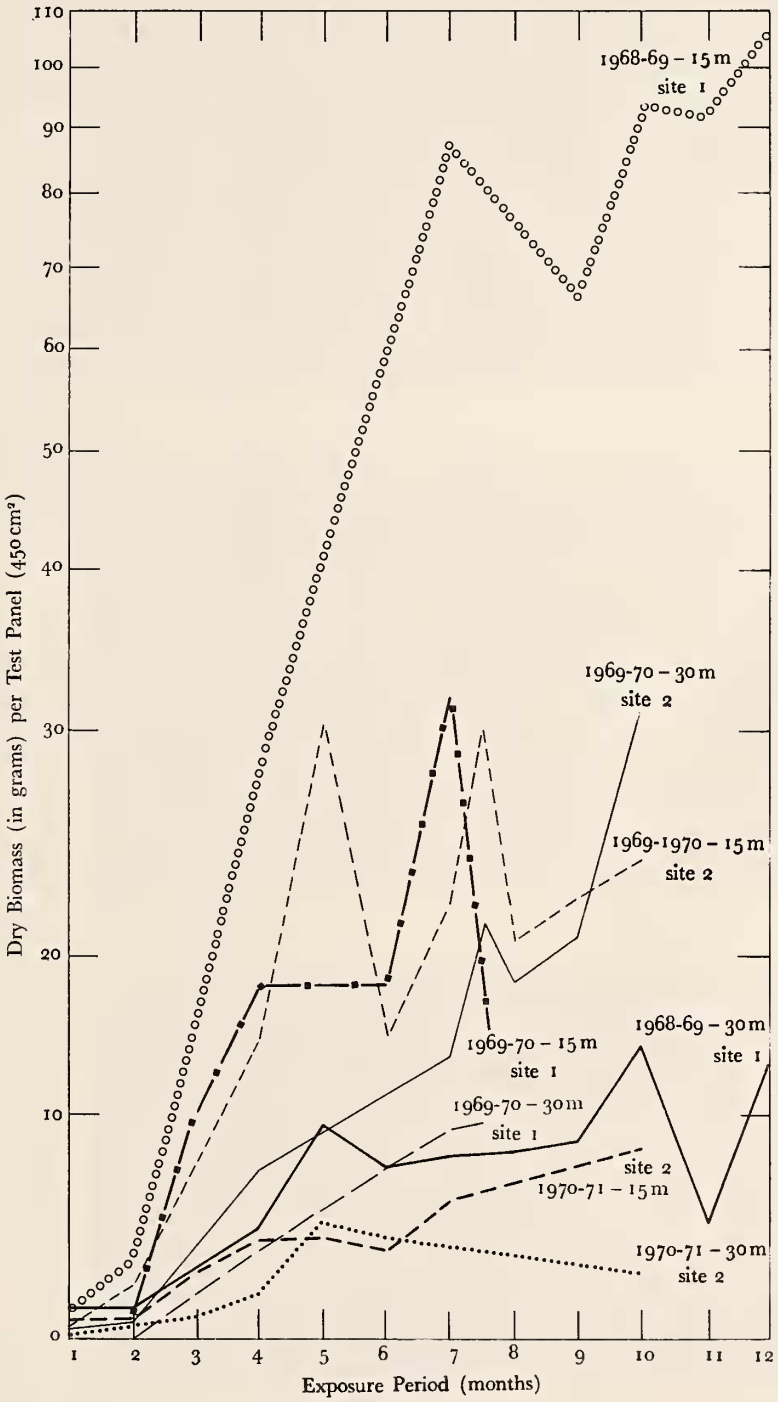


Figure 5

Dry Biomass of Fouling at Sites 1 and 2 from 1968 to 1971, at the 30 meter and 15 meter levels

ate offshore (sites 1 and 2) and severe in the entrance to Pearl Harbor (site 3).

Community Composition

The composition of the fouling assemblages was diverse particularly at the 15 m depth at sites 1 and 2 (Table 1). Mean colonization rates (Figure 3) were plotted for these sessile organisms with the method described by SIMBERLOFF & WILSON (1969). In Pearl Harbor the mean number of species peaked after 3 months exposure and thereafter gradually declined, probably due to increased competition for space, loss of some species (*e. g.*, hydroids, algae, bryozoans) due to crowding, and other successional processes. However, this generalization may be spurious since beyond the 3-months period, the number of samples was very small. On offshore test panels the mean number of species increased rapidly in the first 9 months of community development. Thereafter, the species count appeared to change insignificantly with time.

During development of the fouling communities, a succession of different species was observed at all three sites. At site 3 *Balanus eburneus* and *Didemnum* sp. usually dominated 1- and 2-months assemblages. Some 2-months test panels, however, were completely covered with the tubeworms *Hydroides norvegica* and *H. crucigera*. After 3 months *B. eburneus* and other barnacles generally decreased in numbers as *Crepidula aculeata, Didemnum* sp., and *Polyclinum vasculosum* increased in numbers. These three species often dominated the assemblages after 8 months (Figure *4*).

At 15 m at sites 1 and 2 *Balanus amphitrite, Hydroides norvegica,* colonial diatoms, the bryozoan *Thalamoporella hawaiiana* were abundant on 1 and 2-months test panels. After 2 to 3 months *Thalamoporella hawaiiana, Salmacina dysteri,* colonial diatoms, and *Ostrea kavaia* were abundant. Finally, after 7 to 10 months the community was composed of numerous species, including *Padina pavonica, Pocillopora cespitosa laysanensis,* and *Ostrea kavaia* (Figure *4*).

At 30 m at sites 1 and 2 *Balanus amphitrite, Hydroides norvegica,* and colonial diatoms were abundant on 1 and 2-months test panels, and *Aetea truncata, Pennaria tiarella,* and *Ostrea kavaia* were common. After 2 to 3 months, colonial diatoms, *A. truncata, O. kavaia, Dictyota divaricata,* and *Padina pavonica* were most abundant. After 7 to 10 months the community was composed mostly of *O. kavaia, P. pavonica,* and *Pocillopora cespitosa laysanensis* (Figure *4*).

Community composition, as determined by this and previous fouling studies, varied from place to place throughout Pearl Harbor and in the offshore waters around Oahu. Fouling at site 3 was similar to that observed from 1935 to 1937 and in 1940 at a nearby coal dock in Pearl Harbor (HUTCHINS, 1949; EDMONDSON, 1944). Few of the species observed at site 3 were important in piling communities farther inland in West, Middle, and East Lochs (EVANS, *et al.*, 1972). Fouling at sites 1 and 2 was somewhat similar to that observed from 1935 to 1937 in Kaneohe Bay and in 1944 off Barber's Point and off the entrance to Pearl Harbor (HUTCHINS, 1949; EDMONDSON & INGRAM, 1939).

Seasonality of Attachment

Water temperature ranged from a low of 21°C in January to a high of 28°C in August. Salinity ranged from 34.4‰ in January to 34.9‰ in late October. These small variations in these parameters apparently had little effect upon the seasonality of attachment, since no seasonal trends were observed. Most species attached year-round, generally in an inconsistent manner. However, some species attached in slightly smaller numbers from February through June. The relative rates and months of attachment of most organisms varied from year to year. For example, *Pennaria tiarella* attached offshore in large numbers during October of 1969, but only a trace occurred during October of 1968 and 1970.

Fouling Biomass and Thickness

Dry weight biomass data are presented in Figure 5. At sites 1 and 2, fouling biomass for any single study year was generally greater at 15 m depth than at 30 m during most months. For example, during the 1969–1970 study year a greater biomass accumulated on the shallower site

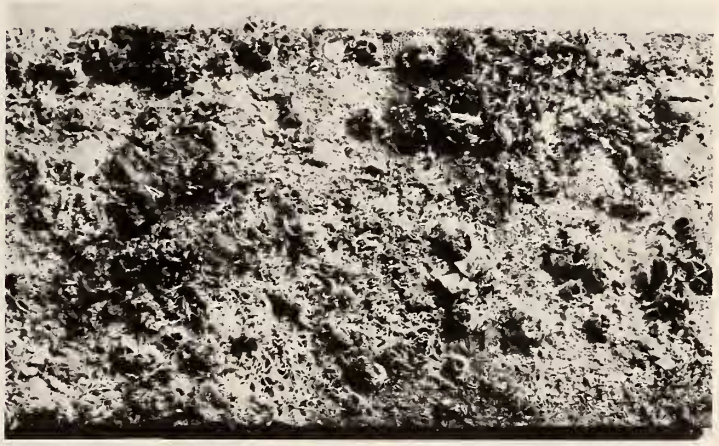
Explanation of Figure *4*

Top – Tunicates, hydroids, mollusks, and barnacles on 8-month test panel at site 3 (9m)

Middle – Barnacles, oysters, tubeworms, algae, and small corals on 13-month test panel at site 2 (15m)

Bottom – barnacles, calcareous algae, oysters, and bryozoans on 13-month test panel at site 2 (30m)
All test panels are 15cm wide


1660



Location/Depth	Site 2 36 m					
Exposure Period (months):	1[1]	2	5	3		
Padina pavonica				0.8		
Dictyota divaricata						
Codium dichotomum						
Pennaria tiarella						
Pocillopora cespitosa			)	0.3		
Bugula neritina		8.0				
Thalamoporella hawaiiana				10.		
Parasmittina spathulata						
Schizoporella unicornis		0.5		3.0		
Watersipora edmondsoni				1.0		
Celleporaria vagans				1.7		
Ostrea kavaia			3			
Crepidula aculeata		1.0				
Sphenia cf. *fragilis*		1.0				
Crucibulum spinosum						
Spondylus gloriosus						
Anomia nobilis						
Pteria loveni						
Pinctada margaritifera						
Pinna muricata				2.5		
Hydroides norvegica						
Balanus eburneus		1.6		0.9		
B. trigonus				0.5		
B. amphitrite		1.2	5	1.8		
B. tintinnabulum						
Herdmania momus		1.1		1.0		
Polyclinum vasculosum						
Ascidia melanostoma						
Didemnum sp.						
Thickness of Hard Fouling:		3.0	5	0.4		

Organisms were measured as follows:

1. Algae except *Padina:* Stipe and/or blade length.
2. *Padina:* Blade diameter.
3. Hydroids: Colony height.
4. Corals: Colony diameter.
5. Erect Bryozoans: Zoarial height at highest point.
6. Encrusting Bryozoans: Zoarial width at widest point.
7. Mollusks: Shell diameter at widest point.
8. Tubeworms: Tube length.
9. Barnacles: Basal diameter.
10. Compound Tunicates: Colony width at widest point.
11. Simple Tunicates: Body length.

[1] No test panels analyzed.

[2] Thickness of fouling on subsurface buoy 8.0 cm as determined by height of *Pocillopora meandrina.*

Table 2

Thickness of Hard Fouling (cm) and Maximum Sizes of Organisms (cm) attached to Asbestos Test Panels exposed for Periods of from 1 to 25 Months, Sites 1 - 3, 1968 - 1972[a]

Location, Depth	Site 3/9 m												Sites 1 & 2/15 m												Sites 1 & 2/30m												Site 2 36 m
Exposure Period (months):	1[a]	2	3	4	5[a]	6	7[a]	8	9	10	11[a]	12	1	2	3	4	5	6	7	8	9	10	11	12	25	1	2	3	4	5	6	7	8	9	10	11	12	25	3
Padina pavonica															0.9	1.5	3.2	2.0	3.8	5.2	7.0	3.0	12	9.0	1.0	0.2		1.1	1.6	5.0	5.0	5.2	6.0	9.0	10	10	8.5	12	0.8
Dictyota divaricata													1.0						1.0								3.0		6.0			8.0			1.6			
Codium dichotomum																0.8		2.2	5.0																			
Pennaria tiarella								25		16		11	1.0	1.0	3.0	1.0	2.0			3.0	2.0	2.0	10			0.5						8.0	8.0		0.5	0.5		
Pocillopora cespitosa													0.2		0.7		0.7	1.2	1.0	1.6	4.8	1.5	6.0	4.5	8.0						0.6	0.6		0.4	0.5	4.2	1.2	6.0	0.3
Bugula neritina	8.0	6.0	4.0		7.0																																	
Thalamoporella hawaiiana		0.5											4.0	6.0	24	20	20	20	20	5.0						1.0	4.5	12.	7.0		20.			20.	1.0		14.		10.
Parasmittina spathulata															3.5									10.				2.0	2.0		2.0						11.		
Schizoporella unicornis	0.5	0.5			0.5							2.5			0.5																							3.0
Watersipora edmondsoni		3.0																	4.5					30.													2.0		1.0
Celleporaria vagans		6.0													1.7													2.0									8.7		1.7
Ostrea kavaia		3.2	1.2				2.0						0.4	1.2	2.2	2.4	2.6	2.3	3.2	2.8	2.5	2.8	3.8	3.8	2.3	0.5	1.4	2.5	2.8	4.0	3.0	3.1	3.8	3.8	3.2	4.0	3.5	3.8	
Crepidula aculeata	1.0	2.4	1.2		2.2		2.5		2.6			2.6			1.8																							
Sphenia cf. fragilis	1.0	0.9	1.2		0.5		1.0		0.8						0.3																							
Crucibulum spinosum		2.2																																				
Spondylus gloriosus																0.8	0.6	1.5	0.7	1.5	1.0	1.5	1.0		0.6		0.3		0.8	0.3		0.5		1.2	1.4		1.4		
Anomia nobilis		2.4													1.0																							
Pteria loveni														0.4			0.9										1.0						5.4		9.0			
Pinctada margaritifera		0.7								2.8			0.5	1.0		2.2	1.7	1.9	3.5	1.9	2.5	2.4	2.0	3.0		0.2	1.2		1.8		5.5	5.5							2.5
Pinna muricata													0.5	1.6	3.0	2.5	3.0	1.4	1.2	2.1	2.0		3.0	3.5		0.5	2.0	1.3	3.1			1.5			2.0	0.7			
Hydroides norvegica		3.0					2.5						1.5	2.0	4.0	3.0										2.0	3.5	3.0	2.5	2.0	2.0		2.0						
Balanus eburneus	1.6	1.6	1.1		1.2		1.4		1.1			1.5		1.2	0.9	1.6								0.9			0.6	1.0									1.3		0.9
B. trigonus		1.8											0.5		1.2	1.2								1.4			0.8	0.7										0.5
B. amphitrite	1.2	1.6	1.1		1.5		1.0		1.0			1.5	0.6	1.7	1.7	1.8	1.6	1.8	1.9	2.0	1.5	1.5	1.9	1.7	1.2	0.4	1.2	1.2	1.8	1.6	1.5	1.7	1.7	1.4	1.2	1.3	1.3	1.5	1.8
B. tintinnabulum																								3.0	5.2													1.0
Herdmania momus	1.1	2.5					3.4								1.5				1.7				2.0															
Polyclinum vasculosum		11			6.0																	3.0	10															
Ascidia melanostoma		5.0																				2.8																
Didemnura sp.		4.0																																				
Thickness of Hard Fouling:	3.0	1.5	2.0		3.0		1.0		2.0				0.2	0.2	0.2	0.2	0.3	0.5	0.4		1.0		1.5		3.0[b]	0	0.2	0.2	0.3	0.6	0.7			0.4	1.0			1.5		0.4

Organisms were measured as follows:

1. Algae except *Padina*: Stipe and/or blade length.
2. *Padina*: Blade diameter.
3. Hydroids: Colony height.
4. Corals: Colony diameter.
5. Erect Bryozoans: Zoarial height at highest point.
6. Encrusting Bryozoans: Zoarial width at widest point.
7. Mollusks: Shell diameter at widest point.
8. Tubeworms: Tube length.
9. Barnacles: Basal diameter
10. Compound Tunicates: Colony width at widest point.
11. Simple Tunicates: Body length.

[a] No test panels analyzed.

[b] Thickness of fouling on subsurface buoy 8.0 cm as determined by height of *Pocillopora meandrina*.